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Deposition of Insecticides on Corn Silks Applied at High and Low Spray Rates for Control of Corn Earworm

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Abstract. *Corn earworm is a major pest of sweet corn, especially when grown organically. Aerial application of insecticides is important for both conventionally- and organically-grown sweet corn production as sweet corn is frequently irrigated to assure return on investment given the high production costs. Aerial insecticide application costs can be minimized through use of reduced spray rates if insecticide efficacy can be maintained at the lower spray rates. The objectives of the study were to characterize deposition on field corn silks when applied at 5 gpa (with VMDs at 230 and 400 µm) and 10 gpa (with VMD at 400 µm) spray rates. Applications of the bioinsecticide, Gemstar®, and the insecticide, Entrust®, which are both approved for use in organic production, were made over three different fields. The amount of spray material deposited on individual silks for each treatment was determined. Deposition of spray material on the silks was very similar across all application treatments. Overall, the 10 gpa rate resulted in the greatest deposition of active material on the corn silks. At the 5 gpa rate, the smaller droplet size sprays resulted in less deposition than the other treatments. Efficacy determinations were attempted by counting the number of larvae of different sizes per ear before and after treatment applications. Heavy reinfestations of ear worms negated much of the efficacy work, but did point out the potential need for timely follow-up treatments.*

Keywords. Aerial application, aerial spraying, spray deposition, corn, corn earworm.

Introduction

Corn earworm, *Helicoverpa zea* (Boddie) is a major insect pest of fresh market and processing sweet corn in the United States (Bartels and Hutchison 1995; Musser and Shelton 2003; Speese et al., 2005). The adult moths are highly mobile, and are capable of laying 2,000 or more eggs over a 12-night period (Hutchison et al. 2004). The adult moth oviposits singly on fresh silks, plant parts such as leaves, husks and stems in the vicinity of emerging silks. Larvae hatch and travel along the silk channel, and begin feeding on kernels within the ear tip. Once the larvae become established within the ear, they are protected by the husk tissue and consequently from insecticidal contact.

The introduction of Bt transgenic technology where a Cry gene from *Bacillus thuringiensis* (Berliner) Bt is transferred to the genome of sweet corn inbreds to create transgenic Bt hybrids has resulted in significant reduction of pesticide use on sweet corn. Although Bt sweet corn hybrids will provide high levels of larval control for growers for processing markets, some insecticide applications are still necessary to obtain increased yield of fresh market quality sweet corn (Burkness et al., 2001; Speese et al., 2005).

The development of application technology designed to obtain maximum control of the pest in conjunction with timely application of pesticides synchronized with peak larval hatch is essential to obtain sweet corn with fresh-market quality. This study is part of a program to develop application technology for aerially-applied insecticides for controlling corn earworm on sweet corn. This test was conducted on field corn because of lack of availability of sweet corn fields in the study area and also because there were no constraints on application of insecticides on field corn.

Objectives

The objectives of the study were to characterize deposition on field corn silks when applied at 5 gpa (with VMDs at 230 and 400 µm) and 10 gpa (with VMD at 400 µm) spray rates. Applications of the bioinsecticide, Gemstar®, and the insecticide, Entrust®, which are both approved for use in organic production, were made over three different fields.

Materials and Methods

Three treatment applications were made on three different fields. Aircraft setup, treatment details, study layout and sampling details follow.

Application Equipment and Treatment Setup

An Air Tractor 402B (Air Tractor, Inc., Olney, TX) was used to make all treatment applications. All treatments were made with CP-11TT nozzles (CP Products, Tempe, AZ). Table 1 shows aircraft and nozzle settings for each treatment. The narrow swath of 45 ft was required to obtain the 10 gpa spray rate for Treatment 3; therefore, the 45 ft swath was also used in treatments 1 and 2. Droplet $D_{V0.5}$ (the volume median diameter is the diameter of droplet such that 50% of the total volume of droplets is in droplets of smaller diameter) was determined using the USDA-ARS Spray Quality models (Kirk, 2007) and the nozzle and aircraft operating parameters.

Table 1. Spray treatment setups and droplet size information.

Treatment	Spray Rate (gpa)	$D_{V0.5}$[a] (μm)	Swath Width (ft)	Orifice Number	Deflection (°)	Spray Pressure (psi)	Airspeed (mph)	Number Nozzles
1	5	230	45	15	90	40	120	37
2	5	400	45	15	10	40	120	37
3	10	400	45	25	30	40	110	40

[a] $D_{V0.5}$ is the volume median diameter which is the diameter of droplet such that 50% of the total volume of droplets is in droplets of smaller diameter.

All three treatments were made with Gemstar (Certis USA, L.L.C., Columbia, MD), which is a naturally occurring virus of *Helicoverpa zea* (corn earworm) making it suitable for organic production. The Gemstar was applied at 10 oz./acre. Tank mix solutions required non-chlorinated water with a pH of 7. Each treatment's spray mixture also contained Caracid Brilliant Flavine fluorescent dye at a rate of 10 g/acre.

Study Layout

Three field locations near Clay, TX (30º25'28N, 96º20'29W) were used in this study. The fields were treated on 3, 6, and 9 June 2008, with three days between each field treatment (1, 2, and 3). At each location, the three treatments were grouped together in three replicate blocks. In each replicate group of three treatments, each treatment plot was flagged for three swath passes. Each treatment plot was sprayed for 600 ft resulting in individual treatment plot sizes of 1.9 ac. For each treatment plot deposition sampling was performed at 60 ft and 120 ft in from the edge of the field along the center swath (Fig. 1). Sampling was done in the center swath to avoid cross contamination between plots. At each of these locations, both mylar and ear silk samples were collected after spray treatment. Five sampling locations were located at each distance. These locations were 15 ft apart with the center location centered on the middle swath (Fig 1). Mylar plate (10 x 10 cm) samples were placed on metal plates attached to electric fence post rods that positioned the mylar at the height of the silks. At each distance, the silk samples were collected at matching locations, 5 rows further into the field (Fig. 1).

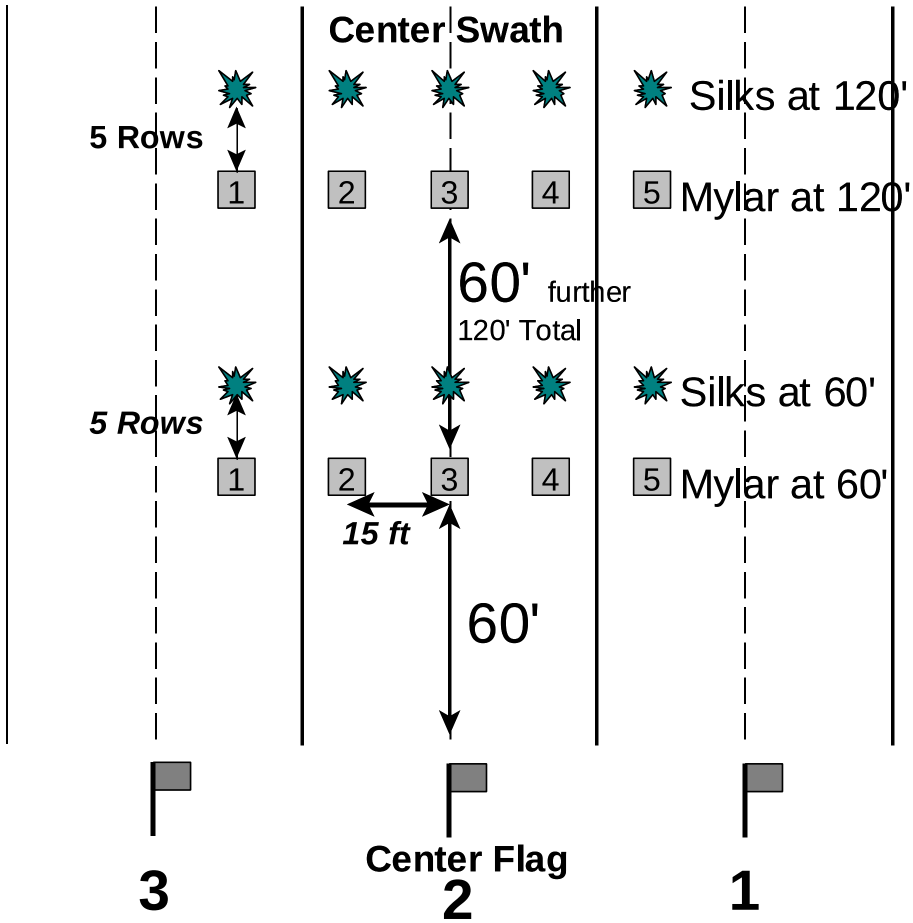

Figure 1. Sampling layout of each treatment plot in each field location.

Sample Collection and Processing

Immediately after each spray treatment was completed, samples were collected from each plot. Mylar cards were collected and placed into labeled plastic zip-bags, and then into ice chests for storage and transport to the processing laboratory. At each silk sampling location, silks were collected from two top ears, one each from plants on opposing rows. For each silk collected, the ear was broken over such that the silk hung downward. A labeled zip-bag was placed under the silk while the silk was cut free with scissors. Bags with collected silks were placed in ice chests like the mylar.

Mylar plate and ear silks samples were washed in 30 mL of ethanol in the collection bags. Samples were agitated to allow time for dye to dissolve into solution in the ethanol. A sample portion of the wash effluent was placed in borosilicate glass culture tubes (12 x 75 mm). The cuvettes were then placed into a spectrofluorophotometer (Shimadzu, Model RF5000U, Kyoto, Japan) with an excitation wavelength of 427 nm and an emission at 489 nm. The fluorometric readings were converted to µL/cm² by comparisons to standards generated using the actual oil and dye mix used. The minimum detection level for the dye and sampling technique was 0.07 ng/cm².

Meteorological Data

Weather parameters were monitored and recorded during all spray applications with a Gill 27005 Anemometer (R. M. Young Company, Traverse City, MI), a Young 43372VC Relative Humidity and Temperature Probe (R. M. Young Company, Traverse City, MI), and a Campbell 21-X data logger (Campbell Scientific, Inc., Logan City, UT). Data was reported as averages and standard deviations by field.

Statistical Analyses

Analysis of the deposition on the mylar and corn silk samples was conducted using SAS PROC MIXED (SAS, 2001). For each set of sampler specific data (i.e. mylar or silks), analysis of variance in deposition was completed with field location and treatment as fixed effects. Random effects included replication, replication within field location, replication by treatment interaction, distance in field by replication, and sub-sampling locations within distance in field and replication.

Results and Discussions

Meteorological Data

Mean and standard deviation data for wind speed, temperature and relative humidity data are reported in Table 2. Temperature and humidity were similar across all three treatments, but wind speed in treatment 1 was double that of the other two treatments.

Table 2. Meteorological data recorded for all three field locations.

Treatment	Wind Speed (mph)	Temperature (°F)	Relative Humidity (%)
1	11.5 ± 1.5	84.7 ± 3.9	70.6 ± 10.2
2	4.8 ± 1.2	82.9 ± 0.7	76.1 ± 2.4
3	5.6 ± 1.1	84.9 ± 1.7	69.1 ± 9.0

Deposition

Analysis using meteorological data as covariates did not show any significant meteorological effects on deposition on either silks or mylar. There was not a significant field location effect on deposition (mass of tracer, i.e. active ingredient, applied at same rate per acre for all treatments, not volume of spray) on either mylar ($P = 0.2851$) or silks ($P = 0.2413$). Therefore, analysis of treatment effects was performed over pooled data across all three field locations. Treatment effects were significant for deposition on both mylar ($P <= 0.0001$) and silks ($P <= 0.0001$). Treatment 3, the 10 gpa spray rate at 400 μm showed the greatest deposition on both mylar and silk collectors. The two 5 gpa treatments showed the minimum deposition on both silks and mylar.

Table 3. Deposition data and separation of means.

Treatment	Sampler Type: Mylar Mean Deposition ($\mu g/cm^2$)	Sampler Type: Silks Mean Deposition ($\mu g/cm^2$)
1	0.08 c	1.6 b
2	0.15 b	1.5 b
3	0.24 a	2.6 a

Means in the same column followed by the same letter are not significantly different based on Duncans' multiple range test (p=0.05)

Discussion and Conclusions

This study was conducted to optimize aerial application technologies for enhanced spray deposition on corn ear silks for control of corn earworm. Conventional hydraulic at nozzles and 5 and 10 gpa spray rates, and at 230 and 400 μm volume median diameters were examined. Overall, the higher rate treatment resulted in the maximum deposition of tracer material, and thus active ingredient, on corn ear silks. The 5 gpa treatments resulted in the least deposition with the smaller droplet spray resulting in less deposition on the mylar, but similar deposition to the larger diameter spray on the silks. The optimal treatment setup was the hydraulic nozzles at 10 gpa with a volume diameter of 400 μm. While being less efficient than the two 5 gpa treatments, this treatment has less drift potential than the smaller-droplet treatment, and maximizes deposition of active ingredient on the spray target.

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